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Nuclear Weapons: The Reliable Replacement Warhead Program

May 24, 2005

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Report Documentation Page			<i>Form Approved OMB No. 0704-0188</i>	
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1. REPORT DATE 24 MAY 2005	2. REPORT TYPE	3. DATES COVERED 00-00-2005 to 00-00-2005		
4. TITLE AND SUBTITLE Nuclear Weapons: The Reliable Replacement Warhead Program			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Congressional Research Service, The Library of Congress, 101 Independence Avenue SE, Washington, DC, 20540-7500			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 35
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified	19a. NAME OF RESPONSIBLE PERSON	

Nuclear Weapons: The Reliable Replacement Warhead Program

Summary

Most current U.S. nuclear warheads were built in the 1980s, and are being retained longer than was planned. Yet warheads deteriorate with age, and must be maintained. The current approach monitors them for signs of aging. When problems are found, a Life Extension Program (LEP) rebuilds components. While some can be made to new specifications, a nuclear test moratorium bars that approach for critical components that would require a nuclear test. Instead, LEP rebuilds them as closely as possible to original specifications. Using this approach, the Secretaries of Defense and Energy have certified stockpile safety and reliability for the past nine years without nuclear testing.

In the FY2005 Consolidated Appropriations Act, Congress initiated the Reliable Replacement Warhead (RRW) program by providing \$9 million for it. The program will study developing replacement components for existing weapons, trading off features important in the Cold War, such as high yield and low weight, to gain features more valuable now, such as lower cost, elimination of some hazardous materials, greater ease of manufacture, greater ease of certification without nuclear testing, and increased long-term confidence in the stockpile. It would modify components to make these improvements; in contrast, LEP makes changes mainly to maintain existing weapons. Representative David Hobson, RRW's prime sponsor, views it as part of a comprehensive plan for the U.S. nuclear weapons enterprise that would also modernize the nuclear weapons complex, avoid new weapons and nuclear testing, and permit a reduction in non-deployed weapons. The FY2006 request is \$9.4 million.

RRW supporters assert LEP will become harder to sustain for the long term as small changes accumulate, making it harder to certify warhead reliability and safety and perhaps requiring nuclear testing. Supporters believe RRW will enable design of replacement components for existing warheads that will be easier to manufacture and certify without nuclear testing, and will permit the military to eliminate many non-deployed warheads it maintains, at high cost, to hedge against potential warhead or geopolitical problems. Skeptics believe LEP and related programs can maintain the stockpile indefinitely. They worry that RRW's changes may reduce confidence and make a return to testing more likely. They question cost savings; even if RRW could lower operations and maintenance cost, its investment cost would be high. They are concerned that RRW could be used to build new weapons that would require testing. They note that there are no military requirements for new weapons.

At issue for Congress is which approach — LEP, RRW, some combination, or something else — will best maintain the nuclear stockpile indefinitely. RRW bears on other issues of interest to Congress, including new weapons development, nuclear testing, restructuring of the nuclear weapons complex, costs of nuclear programs, and nuclear nonproliferation. This report will be updated as events warrant.

Contents

Background	1
Issue Definition	1
Congress, Nuclear Policy, and RRW	2
The Need to Maintain Nuclear Warheads for the Long Term	5
The Solution So Far: The Life Extension Program	8
Is LEP Satisfactory for the Long Term?	10
RRW and the Transformation of Nuclear Warheads	11
RRW and the Transformation of the Nuclear Weapons Enterprise	14
Skeptics' Views of RRW	17
Issues for Congress	19
Are the Surveillance Program and LEP Sufficient to Maintain the Stockpile?	19
Is RRW Needed in Order to Provide New Military Capabilities?	20
Might RRW Permit a Reduction in Warhead Numbers?	21
Will RRW Save Money?	22
How Might RRW Affect the Nuclear Weapons Complex?	23
Might RRW Undermine U.S. Nonproliferation Efforts?	24
Might LEP or RRW Lead to Nuclear Testing?	25
Might RRW Enable an Increase In Inherent Warhead Security?	26
Might RRW Enable an Increase In Warhead Safety?	27
Might RRW Reduce Adverse Consequences of Aging?	28
Might RRW Enable Reduced Use of Hazardous Materials?	28
Policy Options for Congress	29
Appendix: Nuclear Weapons and the Nuclear Weapons Complex	31

Nuclear Weapons: The Reliable Replacement Warhead Program

Background

Issue Definition

Nuclear warhead components deteriorate with age. Without periodic maintenance, warheads might not detonate as intended or might fail to meet safety, security, and other requirements. Congress is poised to review alternative methods to maintain the nuclear stockpile for the long term. The current method, the Life Extension Program (LEP), replaces deteriorated components. Some, such as the outer casing or certain electronics, can be modified, but LEP replaces those in the nuclear explosive package (see Appendix) with newly-produced components manufactured using original designs and, insofar as possible, original materials. Congress created a program, Reliable Replacement Warhead (RRW), in the FY2005 Consolidated Appropriations Act to study a new approach to maintaining warheads over the long term. RRW would redesign components to be easier to manufacture, among other characteristics. The Nuclear Weapons Council, a joint Department of Defense (DOD) and Department of Energy (DOE) organization that oversees nuclear weapons activities, views RRW as the foundation of a plan to transform the entire nuclear weapons enterprise to one with a smaller yet more capable production base and far fewer spare warheads. The issue for Congress is how best to maintain the nuclear stockpile for the long term. A decision on this issue is important because, through it, Congress may affect the characteristics of U.S. nuclear forces; their ability to carry out their assigned missions; perceptions of U.S. nuclear nonproliferation policy; the capabilities and modernization of the nuclear weapons complex; and the nuclear weapons budget.

Many find RRW to be confusing because it is a new program and descriptions of it have changed. To provide a clearer understanding of what RRW seeks to achieve, this report describes the current LEP and difficulties ascribed to it by its critics; shows how post-Cold War changes in constraints may open opportunities to improve long-term warhead maintenance and reach other goals; presents views of LEP supporters; and presents issues and options for Congress. A brief appendix describes nuclear weapon design and operation and the nuclear weapons complex. This report does not consider the larger questions of retaining U.S. nuclear weapons or the strategic uses and values of such weapons.

A note on terminology: RRW is in early stages of a study. It has not produced any hardware. This report refers to “RRW components” and “RRW warheads” as shorthand for components that might be developed under RRW, should that program proceed successfully, and warheads incorporating RRW components.

Congress, Nuclear Policy, and RRW

Congress has been involved with nuclear weapons issues since the Manhattan Project of World War II,¹ addressing issues ranging from strategy and doctrine to force structure and operations.

In the Floyd D. Spence National Defense Authorization Act for FY2001, P.L. 106-398, section 1041, Congress directed the Administration to undertake a Nuclear Posture Review (NPR). This review, which the Administration presented to Congress in January 2002, set forth a new view of the role of nuclear weapons in U.S. defense policy.² It recognized that the strategic relationship with Russia had changed dramatically since the end of the Cold War, and that new and poorly-defined threats could emerge. Accordingly, it called for a change in the nuclear posture from one based on countering a specific threat from the Soviet Union to one that would have a set of capabilities to counter a range of potential future threats, such as the increasing use by potential adversaries of hardened and deeply buried facilities. These capabilities were unified in a “New Triad.” Beginning in the early 1960s, the United States had a “triad” of nuclear forces — bombers, land-based intercontinental ballistic missiles, and submarine-launched ballistic missiles. The New Triad included offensive strike capabilities, which combined the “old” nuclear triad with precision strike conventional forces; missile defenses; and an industrial infrastructure, nuclear and nonnuclear, responsive to DOD needs.

The Administration has indicated that it welcomes a dialog with Congress on broad nuclear policy.³ At the same time, Congress has tended to focus on several

¹ Richard Hewlett and Oscar Anderson, Jr., *A History of the United States Atomic Energy Commission: Volume I, The New World, 1939/1946*, University Park, PA, Pennsylvania State University Press, 1962, p. 289-290, discusses the handling of appropriations for the project.

² The NPR was prepared in classified form; DOD provided unclassified briefing slides and an unclassified briefing on it. For the briefing, see U.S. Department of Defense. News Transcript: “Special Briefing on the Nuclear Posture Review,” J.D. Crouch, Assistant Secretary of Defense for International Security Policy, presenter, January 9, 2002, at [http://www.defenselink.mil/transcripts/2002/t01092002_t0109npr.html]. For the slides, see U.S. Department of Defense. “Findings of the Nuclear Posture Review,” January 9, 2002, at [<http://www.defenselink.mil/news/Jan2002/020109-D-6570C-001.pdf>]. See also U.S. Congress. Congressional Research Service. *Nuclear Weapons: Changes in Policy and Force Structure*. CRS Report RL31623, by Amy Woolf.

³ In a prepared statement to Congress, General James Cartwright, USMC, said: “And finally, as an element of our role as steward of the nation’s strategic nuclear capabilities, we need you to ... [c]onsider a new national dialogue on nuclear policy.” “Statement of General James E. Cartwright, USMC, Commander, United States Strategic Command, before the Senate Armed Services Committee, Strategic Forces Subcommittee, on Strategic Forces and Nuclear Weapons Issues in Review of the Defense Authorization Request for Fiscal Year 2006,” April 4, 2005, p. 15-16. NNSA Administrator Linton Brooks, in a prepared statement to Congress, said, “The Administration is eager to work with the Congress to forge a broad consensus on an approach to stockpile and infrastructure transformation.” “Statement of Ambassador Linton F. Brooks, Administrator, National Nuclear Security

(continued...)

specific issues. In the FY2005 budget cycle, for example, it focused on the Robust Nuclear Earth Penetrator (RNEP), often called the “bunker buster,” a study to determine if an existing nuclear bomb could be modified to penetrate the ground before exploding to increase its effectiveness against buried targets. Congress also considered the Advanced Concepts Initiative (ACI), a program to study nuclear weapon-related technologies.⁴

In debate on FY2005 defense authorization bills, the House and Senate defeated amendments to terminate RNEP and ACI, leaving the full amount requested, \$27.6 million for RNEP and \$9.0 million for ACI, in the FY2005 National Defense Authorization Act (P.L. 108-375). In contrast, the House Appropriations Committee’s energy and water bill eliminated funding for both programs at the urging of Representative David Hobson, Chairman of the Energy and Water Development Appropriations Subcommittee. That subcommittee has jurisdiction over the National Nuclear Security Administration (NNSA), which operates the nuclear weapons program. This position was not challenged on the House floor. The Senate Appropriations Committee did not report an energy and water bill for FY2005. Conferees on the FY2005 Consolidated Appropriations Act (P.L. 108-447), which included energy and water provisions, followed the House position on RNEP and ACI and, at the urging of Representative Hobson, transferred all ACI funds to RRW, a new program created by the bill. The entire description of RRW in the conference report was a “program to improve the reliability, longevity, and certifiability of existing weapons and their components.”⁵

Consistent with congressional action, NNSA included \$9.4 million for RRW in its FY2006 budget request.⁶ Like the description in the conference report, the

³ (...continued)

Administration, U.S. Department of Energy, before the Senate Armed Services Committee, Subcommittee on Strategic Forces,” April 4, 2005, p. 7. Hereinafter “Brooks statement to Senate Armed Services Committee, April 4, 2005.”

⁴ For history and technology of these programs, see CRS Report RL32130, *Nuclear Weapon Initiatives: Low-Yield R&D, Advanced Concepts, Earth Penetrators, Test Readiness.*, by Jonathan Medalia. For the current situation with RNEP, see CRS Report RL32347, *Robust Nuclear Earth Penetrator Budget Request and Plan, FY2005-FY2010*, by Jonathan Medalia.

⁵ U.S. Congress. Committee of Conference .*Making Appropriations for Foreign Operations, Export Financing, and Related Programs for the Fiscal Year Ending September 30, 2005, and For Other Purposes*, conference report to accompany H.R. 4818, H.Rept. 108-792, 108th Congress, 2nd Session, 2004, reprinted in U.S. Congress. *Congressional Record*, November 19, 2004, Book II: H10556.

⁶ To clarify a point of confusion, the FY2006 NNSA budget request shows an aggregate request for FY2006-FY2010 of \$97.1 million. NNSA had insufficient time between December 8, 2004, when P.L. 108-375 was signed, and February 7, 2004, when the budget request was sent to Congress, to prepare a detailed program and cost estimate. Further, Congress had directed that NNSA transfer ACI funds to RRW for FY2005. Accordingly, NNSA relabeled the ACI budget line as RRW. Thus the \$97.1 million should be viewed as a placeholder, not an estimate. Note: budget figures are from U.S., Department of Energy, Office of Management, Budget, and Evaluation/CFO, *FY2006 Congressional Budget* (continued...)

request takes a narrow view of RRW, stating that that program “is to demonstrate the feasibility of developing reliable replacement components that are producible and certifiable for the existing stockpile. The initial focus will be to provide cost and schedule efficient replacement pits [see Appendix] that can be certified without Underground Tests.”⁷

Based on such statements, and on discussions with adherents of various points of view, it appears that RRW can be described as follows:

RRW is a new congressionally-mandated program. Under it, the National Nuclear Security Administration (NNSA) will conduct a two-year study beginning in FY2005 to determine if a new philosophy for refurbishing nuclear warheads to reflect current constraints and opportunities can lead to a process for manufacturing warheads and certifying their performance. It appears that this process has as its direct goal the manufacture of new-design replacement warhead components using best modern manufacturing practices to give future nuclear weapon designers and manufacturers increased confidence, without nuclear testing, in their ability to maintain warheads so that they will perform as intended over the long term. Other goals include increased ease of manufacture and certification, increased responsiveness to possible future military requirements, reduced life cycle cost, reduced likelihood of nuclear testing, increased weapon safety and security, and increased responsiveness to environmental, safety, and health concerns

To achieve these goals, RRW would make several key tradeoffs, sacrificing (assuming Department of Defense approval) warhead characteristics important during the Cold War but less so now, such as weight, size, yield, and efficiency.

The main difference between RRW and the current approach to stockpile maintenance, the Life Extension Program (LEP), is one of an underlying philosophy. Under RRW, NNSA would make changes to weapon components, including those in the nuclear explosive package in an effort to attain the foregoing goals. Under LEP, NNSA makes changes chiefly to maintain weapons, and in particular minimizes changes to the nuclear explosive package. Most of the changes under RRW probably could be made under LEP. However, they probably would not be because LEP strives to hold changes to a minimum.

Supporters anticipate that RRW offers a path to two larger goals: replacing a large nuclear weapons stockpile with fewer but more reliable weapons, and restructuring the nuclear weapons complex into one that is smaller, safer, more efficient, more responsive, and less costly. Skeptics question whether some of the tradeoffs and goals are feasible, necessary, or worth potential costs and risks.

⁶ (...continued)

Request. Volume I, National Nuclear Security Administration. DOE/ME-0046, February 2005, p. 68. NNSA provided information on the change from ACI to RRW.

⁷ Department of Energy, *FY2006 Congressional Budget Request*, Volume I, p. 82.

The Need to Maintain Nuclear Warheads for the Long Term

Nuclear warheads must be maintained because they contain thousands of parts that deteriorate at different rates. Some parts, such as tritium reservoirs and neutron generators,⁸ and materials, such as tritium, have well-known life limits, while the service life of other parts may be unknown or revealed only by multiple inspections of a warhead type over time. A 1983 report arguing that maintenance requires nuclear testing, stated:

Certain chemically reactive materials are inherently required in nuclear weapons, such as uranium or plutonium, high explosives, and plastics. The fissile materials, both plutonium and uranium, are subject to corrosion. Plastic-bonded high explosives and other plastics tend to decompose over extended periods of time. ... portions of materials can dissociate into simpler substances. Vapors given off by one material can migrate to another region of the weapon and react chemically there. ... Materials in the warhead electrical systems ... can produce effluents that can migrate to regions in the nuclear explosive portion of the weapon. ... The characteristics of high explosives can change with time. ... Vital electrical components can change in character ...⁹

A 1987 report, written to rebut the contention of the foregoing report that nuclear testing is needed to maintain nuclear weapons, nonetheless agreed that aging affects weapon components:

It should also be noted that nuclear weapons engineering has benefitted from a quarter century of experience in dealing with corrosion, deterioration, and creep since the time that the W45, W47, and W52 [warheads] entered the stockpile in the early sixties (just after the test moratorium of 1958-1961). ... Most of the reliability problems in the past have resulted from either an incomplete testing program during the development phase of a weapon or the aging and deterioration of weapon components during deployment.¹⁰

Some feel that deterioration, while a potential problem, has been overstated. A scientific panel writing in 1999 stated,

there is no such thing as a “design life.” The designers were not asked or permitted to design a nuclear weapon that would go bad after 20 years. They did their best on a combination of performance and endurance, and after experience with the weapon in storage there is certainly no reason to expect all of the

⁸ U.S. General Accounting Office. *Nuclear Weapons: Capabilities of DOE's Limited Life Component Program to Meet Operational Needs*, Letter Report, GAO/RCED-97-52, March 5, 1997, available at [<http://www.globalsecurity.org/wmd/library/report/gao/rced97052.htm>].

⁹ “Some Little-Publicized Difficulties with a Nuclear Freeze,” Prepared by Dr. J.W. Rosengren, R&D Associates, under Contract to the Office of International Security Affairs, U.S. Department of Energy, October 1983, p. 5-6; reprinted in U.S. Congress. Senate. Committee on Foreign Relations. *Nuclear Testing Issues*. 99th Congress, 2nd Session, Senate Hearing 99-937, 1986, p. 167-168.

¹⁰ Ray Kidder, *Stockpile Reliability and Nuclear Test Bans: Response to J.W. Rosengren's Defense of His 1983 Report*, Report UCID-20990, Lawrence Livermore National Laboratory, February 1987, p. 4-5.

nuclear weapons of a given type to become unusable after 20 or 25 years. In fact, one of the main goals of SBSS [Science-Based Stockpile Stewardship, an earlier term for the Stockpile Stewardship Program, discussed below] is to predict the life of the components so that remanufacture may be scheduled, and results to date indicate a margin of surety extending for decades. ... Until now, clear evidence of warhead deterioration has not been seen in the enduring stockpile, but the plans for remanufacture still assume that deterioration is inevitable on the timescale of the old, arbitrarily defined “design lives.”¹¹

The deterioration noted above pertained to warheads designed in the 1950s and early 1960s and no longer deployed; newer warheads correct some of these problems. As knowledge of warhead performance, materials, and deterioration increases, the labs are able to correct some problems and forestall others. Still other aging problems have turned out to occur at a slower pace than was feared. In particular, it was long recognized that plutonium would deteriorate as it aged, but it was not known how long it would take for its deterioration to impair warhead performance. Now, studies are underway to find out, and the current best estimate is that it would take at least 45 to 60 years.

Any consequences of deterioration problems that arose during the Cold War were limited in their duration because warheads had little time to age. The United States introduced generation after generation of new nuclear “delivery vehicles”—bombers, missile submarines, and land-based missiles — each of which would typically carry a new-design warhead tailored to its characteristics and mission. A warhead for a new missile, for example, might have to withstand a higher acceleration, have a higher explosive yield, and be constrained to a specific volume. New warheads were usually introduced long before the warheads they replaced reached the end of their service lives. Two trends concerning deterioration have emerged since the end of the Cold War. Nuclear warheads have much more time to age, as warheads expected to remain in the stockpile for at most 20 years are being kept there indefinitely. At the same time, Stockpile Stewardship and other tools described below have greatly increased NNSA’s understanding of warhead deterioration and how to deal with or prevent it. Also, by maintaining the current set of warhead designs for many years, design and production errors have been subjected to systematic identification and elimination.

Nuclear warheads are difficult to maintain. Yet an inability to maintain warheads could erode the confidence of the United States, its friends and allies, and its adversaries in the effectiveness of U.S. nuclear forces.

Nuclear warheads must be maintained so that the United States, its friends and allies, and its adversaries will be confident about the effectiveness of U.S. nuclear forces. Yet warheads are hard to maintain not only because of deterioration, but also because of their design. They were designed to an exacting set of constraints. They had to meet so-called Military Characteristics set forth by DOD in consultation with DOE that specified safety parameters, weight, size, and yield, as well as the conditions a warhead would encounter in its lifetime, such as temperature and

¹¹ Sidney Drell, Raymond Jeanloz, et al., *Remanufacture*, MITRE Corporation, JASON Program Office, JSR-99-300, October 1999, p. 4, 8.

acceleration. Design compromises were made to meet these constraints. For example, beryllium was used in warheads even though it is toxic and hard to machine, and more energetic explosives were sometimes used instead of substantially less energetic ones despite an increased safety risk. Design was usually done with little consideration for ease of manufacture. Ambassador Linton Brooks, NNSA Administrator, has said that to meet the various requirements, especially maximizing yield while minimizing size and weight, “we designed these systems very close to performance cliffs.”¹² That is, designs approached the point at which warheads would fail.¹³

A consequence of this design approach was that warhead components could be hard to replicate. Indeed, according to Brooks, “it is becoming more difficult and costly to certify warhead remanufacture. The evolution away from tested designs resulting from the inevitable accumulations of small changes over the extended lifetimes of these systems means that we can count on increasing uncertainty in the long-term certification of warheads in the stockpile.”¹⁴

At issue is whether warheads can be maintained despite the absence of nuclear testing by replacing deteriorated components with newly-made ones built as close as possible to the original specifications. This debate has been going on for decades. In a 1978 letter to President Carter, three weapons scientists argued that the United States could go to great lengths in remanufacturing weapon components:

it is sometimes claimed that remanufacture may become impossible because of increasingly severe restrictions by EPA or OSHA to protect the environment of the worker. ... if the worker’s environment acceptable until now for the use of asbestos, spray adhesives, or beryllium should be forbidden by OSHA regulations, those few workers needed to continue operations with such material could wear plastic-film suits ... It would be wise also to stockpile in appropriate storage facilities certain commercial materials used in weapons manufacture which might in the future disappear from the commercial scene.¹⁵

However, in a 1987 report, three scientists at Lawrence Livermore National Laboratory stated:

¹² U.S. Congress. Senate. Committee on Armed Services. Subcommittee on Strategic Forces. Hearing: Strategic Forces/Nuclear Weapons Fiscal Year 2006 Budget, April 4, 2005. Hereinafter “Senate Armed Services Committee hearing, Strategic Forces/Nuclear Weapons, April 4, 2005.”

¹³ For example, if designers calculated that a certain amount of plutonium was the minimum at which the warhead would work, they might add only a small extra amount as a margin of assurance.

¹⁴ Brooks statement to Senate Armed Services Committee, April 4, 2005, p. 3.

¹⁵ Letter from Norris Bradbury, J. Carson Mark, and Richard Garwin to President Jimmy Carter, August 15, 1978, reprinted in U.S. Congress. House. Committee on Foreign Affairs and Its Subcommittee on Arms Control, International Security and Science, *Proposals to Ban Nuclear Testing*, hearings and markup on H.J.Res. 3, 99th Congress, 1st Session, 1985, p. 215.

- *Exact replication, especially of older systems, is impossible.* Material batches are never quite the same, some materials become unavailable, and equivalent materials are never exactly equivalent. “Improved” parts often have new, unexpected failure modes. Vendors go out of business ...
- *Documentation has never been sufficiently exact to ensure replication.* ... We have never known enough about every detail to specify everything that may be important. ...
- *The most important aspect of any product certification is testing; it provides the data for valid certification.*¹⁶

Clearly, if components could be remanufactured to identical specifications, using identical materials, indefinitely, then warheads could be maintained in this manner as long as needed, with little in the way of scientific advances required. But NNSA holds that a more comprehensive program is needed.

The Solution So Far: The Life Extension Program

With the end of the Cold War, the nuclear weapons complex, like the rest of the defense establishment, faced turmoil. Budgets and personnel were slashed, design of new weapons ended, and a test moratorium began. For a time, the chief concern of DOE’s nuclear weapons management was survival of the nuclear weapons complex.

To address this concern and set a course for the nuclear weapons enterprise, Congress, in Section 3138 of P.L. 103-160, the FY1994 National Defense Authorization Act, directed the Secretary of Energy to “establish a stewardship program to ensure the preservation of the core intellectual and technical competencies of the United States in nuclear weapons, including weapons design, system integration, manufacturing, security, use control, reliability assessment, and certification.” Since then, the Clinton and Bush Administrations have requested, and Congress has approved, tens of billions of dollars for this Stockpile Stewardship Program (SSP), which is presented in NNSA’s budget as “Weapons Activities.”

SSP uses data from past nuclear tests, small-scale laboratory experiments, large-scale experimental facilities, examination of warheads, and the like to improve theoretical understanding of the science underlying nuclear weapons performance. In turn, it uses this knowledge to improve computer “codes” that simulate aspects of weapons performance, revealing aspects of this performance and filling gaps in the nuclear weapons laboratories’ understanding of it. Such advances enable scientists to analyze data from past nuclear tests more thoroughly, “mining” it to extract still more information. Theory, simulation, and data reinforce each other: theory refines

¹⁶ George Miller, Paul Brown, and Carol Alonso, *Report to Congress on Stockpile Reliability, Weapon Remanufacture, and the Role of Nuclear Testing*, Lawrence Livermore National Laboratory report UCRL-53822, October 1987, p. 25. For an opposing view, see R.E. Kidder, *Maintaining the U.S. Stockpile of Nuclear Weapons During a Low-Threshold or Comprehensive Test Ban*, Lawrence Livermore National Laboratory report UCRL-53820, October 1987, esp. p. 6-9. See also U.S. Congress. Congressional Research Service. *Nuclear Weapons Production Capability Issues*, CRS Report 98-519 F, June 8, 1998, by Jonathan Medalia, esp. p. 97-102.

simulation, simulation helps check theory, theory and simulation guide researchers to look for certain types of data, and data help check simulation and theory.

A key task of the weapons complex is to monitor warheads for signs of actual or future deterioration. This work is done through a program that conducts routine surveillance of warheads in the stockpile by closely examining 11 warheads of each type per year to search for corrosion, gases, and other evidence of deterioration. Of the 11, one is taken apart for destructive evaluation, while the other 10 are evaluated nondestructively and returned to the stockpile.¹⁷ In addition, an Enhanced Surveillance Program (ESP) supports surveillance; its goal “is to develop diagnostic tools and predictive models that will make it possible to analyze and predict the effects that aging may have on weapon materials, components, and systems.”¹⁸

When routine surveillance detects warhead problems, the nuclear weapons program applies knowledge gained through SSP to fix problems through the Life Extension Program (LEP). It attempts “to extend the stockpile lifetime of a warhead or warhead components at least 20 years with a goal of 30 years”¹⁹ in addition to the originally-anticipated deployment time.

A warhead’s components may be divided into two categories: those that are part of the nuclear explosive package (NEP), and those that are not. As described in the Appendix, the NEP is the part of the warhead that explodes, as distinct from the more numerous components like the outer case or arming system. Because non-NEP components can be subjected to extensive experiments and nonnuclear laboratory tests, they can be modified as needed under LEP to incorporate more advanced electronics or better materials. In sharp contrast, NEP components cannot be subjected to nuclear tests because the United States has observed a moratorium on nuclear testing since 1992. As a result, LEP seeks to replicate these components using original designs and, insofar as possible, original materials. In this way, it is hoped, components will be close to the originals so that they can be qualified for use in warheads. Because NEP components cannot be tested while other components can be, long-term concern for both LEP and RRW focuses on NEP components.

Warheads contain several thousand components. While not all need to be refurbished in an LEP, some are difficult to fabricate. As a result, the LEP for a particular warhead is a major campaign with extensive preparatory analysis and detailed work on many components that can take many years. For example, NNSA describes the LEP for the W76 warhead for Trident submarine-launched ballistic missiles as follows:

The W76 Life Extension Program will extend the life of the W76 for an additional 30 years with the FPU [first production unit] in FY 2007. Activities will include design, qualification, and certification activities to ensure the design

¹⁷ Information provided by NNSA, May 9, 2005.

¹⁸ Katie Walter, “Enhanced Surveillance of Aging Weapons,” *Science & Technology Review*, January/February 1998: 21.

¹⁹ Department of Energy, *FY2006 Congressional Budget Request*, Volume I, p. 75. For a weapon-by-weapon description of LEP activities planned for FY2006, see *ibid.*, p. 75-76.

of the refurbished warheads meets all required military characteristics; work associated with the manufacturability of the components including the nuclear explosive package; the Arming, Fuzing, and Firing (AF&F) system; the gas transfer system; and the associated cables, elastomers, valves, pads, foam supports, telemetries, and miscellaneous parts.²⁰

Stockpile Stewardship has made great strides in understanding weapons science, in predicting how weapons will age, and in predicting how they will fail. Most observers agree with the following assessment by Brooks in congressional testimony of April 2005:

today *stockpile stewardship is working*, we are confident that the stockpile is safe and reliable, and there is no requirement at this time for nuclear tests. Indeed, just last month, the Secretary of Energy and Secretary of Defense reaffirmed this judgment in reporting to the President their ninth annual assessment of the safety and reliability of the U.S. nuclear weapons stockpile. ... Our assessment derives from ten years of experience with science-based stockpile stewardship, from extensive surveillance, from the use of both experiments and computation, and from professional judgment.²¹

Is LEP Satisfactory for the Long Term?

In the turmoil following the end of the Cold War, it is scarcely surprising that the method chosen to maintain the stockpile — a task that had to be performed in the face of the many changes affecting the weapons complex, and the many unknowns about its future — was to minimize changes. Now, with SSP well established, NNSA feels that it is appropriate to use a different approach to warhead maintenance, one that builds on the success of SSP but that challenges the notion underlying LEP that changes must be held to a minimum.

Advocates of RRW recognize that LEP has worked well but, as discussed below, charge that it uses the wrong methods to maintain the wrong stockpile. Their concern is not with maintaining reliability of warheads over the near term, but of *sustaining* reliability over the long term. They assert that LEP is not suited to the task because it will become harder to make it work as the universe in which current warheads were created increasingly recedes from current technology. A universe of archaic technology, it is argued, will become increasingly difficult to support as materials, equipment, processes, and skills become unavailable. If the labs were to lose confidence that they could replicate NEP components to near-original designs using near-original materials and processes, the United States could ultimately face a choice between resuming nuclear tests or accepting reduced confidence in reliability.

Criticism of LEP starts with a particular view of nuclear strategy and the nuclear stockpile. The current stockpile, most units of which were manufactured between 1979 and 1989, was designed to deter and, if necessary, defeat the Soviet Union.

²⁰ Department of Energy, *FY2006 Congressional Budget Request*, Volume I, p. 75.

²¹ Brooks statement to Senate Armed Services Committee, April 4, 2005, p. 2. Original emphasis.

Now, as noted, threat, strategy and missions have changed. Accordingly, in this view, the United States has the wrong stockpile for current circumstances. Brooks said that current warheads are wrong technically because “we would [now] manage technical risk differently, for example, by ‘trading’ [warhead] size and weight for increased performance margins, system longevity, and ease of manufacture.” These warheads were not “designed for longevity” or to minimize cost, and may be wrong militarily because yields are too high and “do not lend themselves to reduced collateral damage.” They also lack capabilities against buried targets or biological and chemical munitions, and they do not take full advantage of precision guidance.²² Furthermore, LEP’s critics believe the stockpile is wrong politically because it is too large:

We retain “hedge” warheads in large part due to the inability of either today’s nuclear infrastructure, or the infrastructure we expect to have when the stockpile reductions are fully implemented in 2012, to manufacture, in a timely way, warheads for replacement or for force augmentation, or to act to correct unexpected technical problems.²³

Finally, they believe the stockpile is wrong in terms of physical security because it was not designed for a scenario in which terrorists seize control of a nuclear weapon and try to detonate it in place. New use control technologies would permit NNSA to reduce the cost of “gates, guns, guards.”²⁴

RRW and the Transformation of Nuclear Warheads

The U.S. nuclear stockpile was designed within Cold War constraints, requirements, and opportunities. While the requirement for warheads to be safe and reliable remains constant, many other constraints have changed — indeed, inverted — over the past 15 years, and new opportunities and requirements have emerged as well. As a result, RRW advocates claim, it is both necessary and feasible to transform the stockpile to reflect these changes.

With RRW, NNSA hopes to revisit tradeoffs underlying the current stockpile to enable it to adapt to changes over the past 15 years and meet possible future requirements. While RRW would change many tradeoffs significantly, the changes would, in NNSA’s view, work out well: NNSA would trade negligible sacrifices to secure major gains. For example, NNSA would consider relaxing constraints on yield and yield-to-weight, assuming DOD approved. So doing would enable NNSA to move to simpler designs, which would be essential in an environment without nuclear testing. NNSA would strive to minimize the use of hazardous materials, and relaxing constraints on yield and on yield to weight would make it easier to do so. The balance of this section presents some Cold War warhead requirements, how they have changed, and implications of these changes.

²² Ibid., pp. 2-3.

²³ Ibid., p. 3.

²⁴ Ibid., p. 4.

Efficiency. A major characteristic of warheads for ballistic and cruise missiles was a high “yield-to-weight ratio”—that is, maximizing a warhead’s explosive force (yield) for a given weight.²⁵ Reducing weight let each missile carry more warheads to more distant targets; increasing yield gave each warhead a better chance of destroying its target; and increasing yield-to-weight enabled these goals to be met at the same time. For example, the W88 warhead for the Trident II submarine-launched ballistic missile, used a conventional high explosive (CHE) that was more sensitive to impact than an alternative, insensitive high explosive (IHE), used on many other warhead types. IHE provided greater safety, but CHE packed substantially more energy per unit weight. A missile could carry the lighter CHE warheads to a greater distance, so that a submarine could stand off farther from its targets. Increased ocean patrol area forced the Soviet Union to spread out its antisubmarine assets, improving submarine survivability. Hard-to-manufacture designs, hazardous materials, and other undesirable features were deemed acceptable design tradeoffs to maximize yield-to-weight. Now, ballistic missiles carry fewer warheads than they did during the Cold War due to reduced targeting requirements. As a result, it is possible to revisit the Cold War tradeoffs, redesigning warhead components to give greater emphasis to other characteristics at the expense of yield, weight, or both. For example, with a missile’s carrying capacity divided among fewer warheads, each warhead can be somewhat heavier,²⁶ and the added permissible weight might be allocated to a design that was easier to manufacture.

Yield. During the Cold War, DOD required a substantial yield for its strategic warheads. Yield compensated for inaccuracy in attacking targets such as missile silos, which were hardened to withstand all but near misses or direct hits. Yield was also important for attacking targets covering large areas, such as shipyards or petroleum refineries. Now, high yield is much less important. It is unclear what area targets there might be in the future. Further, precision guidance enables conventional bombs to score direct hits on targets, and similar technology could apparently be used to make missile-delivered nuclear warheads more accurate, permitting lower yield. Indeed, some argue that the United States needs some lower-yield warheads.²⁷ In this view, lower-yield warheads would create less of the unintended damage that might prevent the United States from using them. Such warheads would be a better deterrent precisely because their use would be more credible.

²⁵ Bombs were less constrained in weight because bombers carry heavier loads than missiles.

²⁶ Ballistic missiles carry warheads inside reentry vehicles (RVs). An RV is a streamlined shell that protects its warhead from the intense heat and other stresses of reentering the atmosphere at high speed. RVs are designed to carry a specific type of warhead on a specific missile; the maximum stress that the RV encounters is carefully studied. Increasing warhead weight significantly would increase these stresses, possibly causing the RV to fail and the warhead to burn up, fail, or miss its target by a wide margin.

²⁷ Bryan Fearey, Paul White, John St. Ledger, and John Immele, “An Analysis of Reduced Collateral Damage Nuclear Weapons,” *Comparative Strategy*, October/November 2003: 313-315. These lower-yield weapons are not necessarily the very low yield “mini-nukes” debated in Congress in recent years.

Nuclear testing. Between 1945 and 1992, the United States conducted over 1,000 nuclear tests, most of which were for weapons design.²⁸ These tests provided confidence that a weapon incorporating hard-to-manufacture components was made correctly, that a weapon would work at the extremes of temperatures to which it might be exposed, and that the design was satisfactory in other ways. Testing also enabled the labs to validate changes to existing warhead designs. With the congressionally-imposed U.S. nuclear test moratorium in October 1992,²⁹ the United States can no longer rely on tests to validate designs. While there are no military requirements for nuclear weapons with new or modified military capabilities,³⁰ any future weapon would have to be more conservatively designed, staying within design parameters validated by past nuclear tests. This conservatism applies as well to modifications of components.

Performance, schedule, and cost tradeoffs. Performance has always been the dominant consideration for nuclear weapons. Weapons must meet standards for safety and reliability, and meet other military characteristics. During the Cold War, schedule was also critical. With new missiles and nuclear-capable aircraft entering the force at a sustained pace, warheads and bombs had to be ready on a schedule dictated by their delivery systems. As a result, “our nuclear warheads were not designed ... to minimize DOE and DoD costs.”³¹ Now, reducing cost has a higher priority. Cost reduction is also more feasible: performance is still dominant, but no external threat drives the schedule.

Environment, safety, and health (ES&H). During much of the Cold War, the urgency of production and the limited knowledge of the ES&H effects of materials used or created in the nuclear weapons enterprise resulted in the use of hazardous materials, dumping contaminants onto the ground or into rivers, exposing citizens to radioactive fallout from nuclear tests, and the like. Now, ES&H concerns have grown within the nuclear weapons complex, reflecting their rise in civil society at large, leading to a strong interest in minimizing the use of hazardous materials in warheads and their production.

Skill development and transfer. During the Cold War, the design of dozens of warhead types, the conduct of over 1,000 nuclear tests, and the production of thousands of warheads exercised the full range of nuclear weapon skills. Now, with no design or testing, no new-design warheads being produced, and with warheads

²⁸ The United States conducted 1,030 tests, of which 883 were weapons related. (The United Kingdom conducted another 24 tests at the Nevada Test Site.) U.S. Department of Energy. Nevada Operations Office. Office of External Affairs. *United States Nuclear Tests, July 1945 through September 1992*, DOE/NV-209, revision 14, December 1994, p. viii.

²⁹ The moratorium was begun pursuant to Section 507 of P.L. 102-377, FY1993 Energy and Water Development Appropriations Act, signed into law October 2, 1992.

³⁰ Brooks stated, “we must preserve the ability to produce weapons with new or modified military capabilities if this is required in the future. *Currently the DoD has identified no requirements for such weapons*, but our experience suggests that we are not always able to predict our future requirements.” Brooks statement to Senate Armed Services Committee, April 4, 2005, p. 6. Emphasis added.

³¹ Brooks statement to Senate Armed Services Committee, April 4, 2005, p. 3.

being refurbished at a slower pace than that at which they were originally produced, some have raised concern that weapons complex personnel are not adequately challenged. In this view, skill development and transfer can no longer be simply a byproduct of the work, but must be an explicit goal of the nuclear weapons program.

RRW and the Transformation of the Nuclear Weapons Enterprise

Supporters see RRW as the basis for much more than addressing warhead issues. Representative Hobson was, as noted, the prime sponsor of the effort to establish RRW. Consequently, it is important to understand his intent for the program. He expressed concern about the direction of nuclear policy. In introducing the FY2005 energy and water bill to the House, he emphasized the need to redirect the nuclear weapons complex:

much of the DOE weapons complex is still sized to support a Cold War stockpile. The NNSA needs to take a ‘time-out’ on new initiatives until it completes a review of its weapons complex in relation to security needs, budget constraints, and [a] new stockpile plan..³²

At a National Academy of Sciences symposium in August 2004, he expressed concern about Administration nuclear policies and programs:

I was not comfortable with the Administration’s emphasis on new nuclear weapons initiatives in the fiscal year 2004 budget request and repeated in the fiscal year 2005 request. I view the Advanced Concepts research proposal, the Robust Nuclear Earth Penetrator study, and the effort to reduce the nuclear test readiness posture to 18 months as very provocative and overly aggressive policies that undermine our moral authority to argue that other nations should forego nuclear weapons. We cannot advocate for nuclear nonproliferation around the globe and pursue more useable nuclear weapon options here at home. That inconsistency is not lost on anyone in the international community.³³

He saw RRW as a key part of his effort to redirect U.S. nuclear strategy, reshape the nuclear weapons stockpile and complex to support that strategy, undertake weapons programs consistent with that strategy, and reject those inconsistent with it.

I think the time is now for a thoughtful and open debate on the role of nuclear weapons in our country’s national security strategy. There is still a basic set of questions that need to be addressed and let me talk about some of those. How large a stockpile should we maintain, should we have a set of older weapons with many spares or should we have a smaller stockpile of more modern weapons?

³² U.S. Congress. *Congressional Record*. June 25, 2004: H5085.

³³ Representative David Hobson, “Remarks by Chairman David Hobson — House Appropriations Subcommittee on Energy and Water Development, [to the] National Academy of Sciences, Committee on International Security and Arms Control, Symposium on ‘Post-Cold War U.S. Nuclear Strategy: A Search for Technical and Policy Common Ground,’” August 11, 2004, p. 3; available at [http://www7.nationalacademies.org/cisac/Hobson_Presentation.pdf].

What design and manufacturing capabilities do we need to maintain the DOE nuclear weapons complex? And where should these complexes be located? And finally, is this the best use of our limited, financial resources for national defense? ... until we have this debate and develop a comprehensive plan for the U.S. nuclear stockpile and the DOE weapons complex, we're left arguing over isolated projects such as the robust nuclear penetrator or the RNEP study. ...³⁴

Representative Hobson also stated:

The Reliable Replacement Warhead concept will provide the research and engineering problems necessary to challenge the workforce while at the same time refurbishing some existing weapons in the stockpile without developing a new weapon that would require underground testing to verify the design. A more robust replacement warhead, from a reliability standpoint, will provide the stockpile hedge that is currently provided by retaining thousands of unnecessary warheads.³⁵

Thus while the FY2005 omnibus appropriations conference report and NNSA's FY2006 budget request presented a program of narrow scope, Representative Hobson envisioned that RRW could be much more consequential. NNSA Administrator Linton Brooks agreed. In testimony of April 2005, he presented an expansive view of the transformation of the nuclear weapons enterprise, with RRW as its pivot point.

Let me briefly describe the broad conceptual approach for stockpile and infrastructure transformation. The "enabler" for such transformation, we believe, is the RRW program. To establish the feasibility of the RRW concept, we will use the funds provided by Congress last year and those requested this year to begin concept and feasibility studies on replacement warheads or warhead components that provide the same or comparable military capabilities as existing warheads in the stockpile. If those studies suggest the RRW concept is technically feasible, and if, as I expect, the Department of Defense establishes a requirement, we should be able to develop and produce by the 2012-15 timeframe a small build of warheads in order to demonstrate that an RRW system can be manufactured and certified without nuclear testing.

Once that capability is demonstrated, the United States will have the option to:

- truncate or cease some ongoing life extension programs for the legacy stockpile,
- apply the savings from the reduced life extension workload to begin to transform to a stockpile with a substantial RRW component that is both easier and less costly to manufacture and certify, and
- use stockpile transformation to enable and drive consolidation to a more responsive infrastructure.³⁶

³⁴ Congressman David Hobson, "U.S. Nuclear Security in the 21st Century," address to the Arms Control Association, Washington, DC, February 3, 2005. (transcript as delivered)

³⁵ Congressman David Hobson, "U.S. Nuclear Security in the 21st Century," address to the Arms Control Association, Washington, DC, February 3, 2005 (remarks as prepared for delivery).

³⁶ Brooks statement to Senate Armed Services Committee, April 4, 2005, p. 6.

DOD, as the “customer” and potential user of nuclear weapons, sets requirements for types and characteristics of nuclear weapons. Representatives of the Office of the Secretary of Defense, the armed services, and NNSA participate in the Nuclear Weapons Council, which under 10 U.S.C. 179 coordinates their efforts in this area. Clearly, if RRW is to progress, it would need the participation and support of DOD, the services, and NNSA. A first step in that direction occurred in March 2005 when the council, by unanimous vote, fully supported the RRW concept. At the same time, RRW, like any program, is subject to congressional approval, rejection, or modification.

Steve Henry, Deputy Assistant to the Secretary of Defense for Nuclear Matters, provided the following statement. It is the first detailed statement of DOD’s position on RRW:³⁷

President Bush said, “I am committed to achieving a credible deterrent with the lowest possible number of nuclear weapons consistent with our national security needs, including our obligations to our allies. My goal is to move quickly to reduce nuclear forces.”³⁸ To achieve this goal, we must have confidence in the safety, security, and reliability of the weapons not just for today, but for the long term and with the goal to reduce the likelihood of resumption of nuclear testing.

Our current path does not adequately meet the President’s guidance. The current stockpile was built in the 80’s. These weapons are optimized for yield-to-weight and were expected to remain in the stockpile for only about 20 years. Under the current life extension program, these weapons would be refurbished to extend their life for more than 30 years beyond their original design life. Although any change to a weapon component is reviewed extensively, there remains an uncertainty on the potential impact of cumulative changes. Fundamentally, the life extension program would continue the reliance on Cold War legacy designs that use toxic and high risk materials and provide only limited opportunity to enhance safety and security with 21st century technology. Additionally, in some cases, the life extension program would require the reconstitution of expensive weapons production processes that were discontinued more than a decade ago. Under the current path, the DoD would continue to depend on non-deployed warheads to hedge against technical failures and against geopolitical changes.

It is in the best interest of the United States to pursue an alternate path. In concept, a reliable replacement warhead (RRW) could provide that path. Ideally, RRW would sustain the military capabilities of the existing stockpile but may require relaxing some of the Cold War design requirements in order to use replacement components. These components would be designed to increase margins, provide for ease of manufacture and certification, and would reduce the potential for failure due to design and manufacturing flaws and material aging issues. These RRW characteristics would improve our ability to ensure long-term confidence in the stockpile and reduce the likelihood of resumption of nuclear testing, therefore potentially reducing the number of warheads needed

³⁷ Statement provided to the author May 3, 2005.

³⁸ President George W. Bush, Remarks by the President to Students and Faculty at National Defense University, Fort Lesley J. McNair, Washington, D.C., May 1, 2001.

to hedge against technical surprises. Under the RRW concept, incorporation of modern safety and security technology would be feasible. RRW could be the enabler for the transformation to an efficient, responsive infrastructure, which may help reduce the number of warheads needed to hedge against geopolitical changes. As an example of how it would make manufacturing easier while increasing safety within the nuclear weapons complex, it could eliminate the need for many of the exotic and hazardous non-nuclear materials.

RRW would, in concept, offer other advantages as well, such as the opportunity to exercise and transfer expertise. However, if we want to move from our current path to RRW, we must do it soon because experienced nuclear weapon designers with test experience are rapidly retiring.

The U.S. Strategic Command (STRATCOM), a component of DOD, is the military command that operates and, at the President's direction, would use U.S. strategic nuclear forces. It provided the following statement on RRW: "STRATCOM will be participating in the joint RRW Project Officers Group, or POG, with the NNSA, the Navy, and the Air Force, and STRATCOM's position on RRW will be based on the results of the RRW POG process."³⁹

Skeptics' Views of RRW

Because RRW is new, not clearly defined, and may hold benefits as well as costs, those who have criticized some past nuclear weapon programs are trying to understand RRW and its implications better. Because they are in the process of shaping their views, there are few outright critics of the program, but some skeptics.

Some Members of Congress take a cautious approach. A letter drafted by Representative Tauscher and others to Representatives C.W. Bill Young and David R. Obey, Chairman and Ranking Member, respectively, of the House Appropriations Committee, and signed by at least 51 Members of Congress, states that RRW "was added in the Omnibus Conference last year to replace Advanced Concepts. The scope and direction of this program must be clearly defined so that this program does not simply replace the one Congress canceled last year." Further, "We are also concerned that shifting funding from the cancelled Advanced Concepts program into the Reliable Replacement Warhead program may result in new nuclear warheads moving forward without any established need or compelling justification."⁴⁰

Robert Peurifoy, a former Vice President of Sandia National Laboratories, feels RRW has been oversold. He sees little difference between RRW and LEP; if a component can be manufactured with materials different than the original under RRW, for example, why couldn't that be done under LEP? He notes that the labs, using development, production, and stockpile data, have repeatedly certified the reliability for the nuclear explosive package of warheads at 100 percent; how, he asks, can that be improved upon? If stockpile stewardship, including LEP as one of its tools, can maintain warheads for nine years without testing, why can it not do so

³⁹ Information provided by STRATCOM to the author, April 29, 2005.

⁴⁰ Letter provided by Representative Tauscher's office; used by permission. For full text, see [<http://www.ananuclear.org/markeys%20letter.html>].

indefinitely? The lack of a military requirement for new-design warheads for many years, and the questionable rationales presented for such warheads in the public debate, in his view, undermines the need for a “responsive” infrastructure, as there will likely be few if any events requiring a response.⁴¹

Raymond Jeanloz is a Professor of Earth and Planetary Science and of Astronomy at the University of California, Berkeley, and a long-time member of scientific panels reporting on nuclear-weapon issues. His view depends on what RRW is. He supports a version of RRW that would build on the success of SSP to improve manufacturing practices, lower costs and increase performance margins, as these enhancements would support the Administration’s decision to significantly reduce the size of the U.S. stockpile. This RRW would stay within the design parameters that have been validated by nuclear testing. In contrast, he opposes an RRW that would move beyond those parameters in order to create new weapons, as that approach could lead to new weapons that are less reliably validated, that require testing, and that would counter U.S. nonproliferation efforts. In particular, he believes that new designs would undermine U.S. attempts to convince other nations not to develop nuclear weapons by showing them that the United States still feels the need for new weapons. Whichever form of RRW emerges, Jeanloz is concerned about the lack of clarity regarding the program and its cost.⁴²

Sidney Drell, Professor Emeritus of Physics at Stanford University, and James Goodby, who held several Administration positions in arms control, including Special Representative of President Clinton for the security and dismantlement of nuclear weapons from 1995 — 1996, both have a view of RRW that depends on how technologically ambitious the program is:

One direct way to simplify the process of certifying the reliability and effectiveness of the warheads and to sustain this confidence over a longer period of time is to increase their performance margins. An example of this is to further enhance the explosive energy provided by the primary stage of a nuclear weapon above the minimum required to ignite the secondary, or main, stage of a nuclear weapon. A straightforward way to do this that requires no explosive testing to validate is by adjusting the boost gas fill in the primary during scheduled maintenance or remanufacturing activities. This is an example of an existing process for maintaining long-term high confidence in the arsenal. It is already available, has high merit, and should continue to be implemented.⁷ This approach is the appropriate focus of effort for the Reliable Replacement Warhead (RRW) program currently being funded at the U.S. national weapons laboratories.

Turning the RRW program into an effort to develop new-warhead designs by altering the nature of the high explosives or the amount of nuclear fuel in the primary without testing, as some have suggested, would be a mistake. It takes an extraordinary flight of imagination to postulate a modern new arsenal composed of such untested designs that would be more reliable, safe, and effective than the

⁴¹ These views are drawn from discussions and emails between Mr. Peurifoy and the author, March-April 2005.

⁴² These views are drawn from discussions and emails between Professor Jeanloz and the author, March-April 2005.

current U.S. arsenal based on more than 1,000 tests since 1945. A comprehensive and rigorous stockpile maintenance program confirms and sustains this high confidence. If testing is resumed, the damage to the broader nonproliferation regime, and thus to U.S. security interests, would far outweigh any conceivable advantages to be gained from the new designs.⁴³

Daryl Kimball, Executive Director of the Arms Control Association, is more concerned:

the [RRW] proposal is problematic. The rationale for the program is dubious, the scope is vague, and the potential effects far-reaching and dangerous. ... new replacement warheads are not necessary to preserve existing U.S. nuclear-weapon capabilities. ... the existing Stockpile Stewardship Program is working. ... the RRW program could, if not carefully circumscribed, become a back door for the administration to circumvent congressional opposition to new warhead designs for new and destabilizing nuclear strike missions. ... replacing existing, well-proven nuclear warhead designs with “new” and “improved” replacement warheads or warhead components could, if carelessly pursued, increase pressure to conduct nuclear explosive proof tests. ... So long as the United States maintains a nuclear arsenal, stockpile maintenance efforts should focus on preserving the reliability of existing warheads using methods validated by past experience.⁴⁴

Issues for Congress

Are the Surveillance Program and LEP Sufficient to Maintain the Stockpile? Skeptics hold that LEP works now, can work indefinitely, and should improve over time. A 2002 report by the National Academy of Sciences stated:

we see no reason that the capabilities of those mechanisms [for maintaining confidence in the stockpile] — surveillance techniques, diagnostics, analytical and computational tools, science-based understanding, remanufacturing capabilities — cannot grow at least as fast as the challenge they must meet. (Indeed, we believe that the growth of these capabilities — except for remanufacturing of some nuclear components — has more than kept pace with the growth of the need for them since the United States stopped testing in 1992, with the result that confidence in the reliability of the stockpile is better justified technically today than it was then.)⁴⁵

⁴³ Sidney Drell and James Goodby, *What Are Nuclear Weapons For? Recommendations for Restructuring U.S. Strategic Nuclear Forces*, Arms Control Association, April 2005, p. 19-20. Footnote in original is as follows: 7. Executive Summary, JASON Report on Nuclear Testing, JSR-95-320 (August 1, 1995).

⁴⁴ Daryl Kimball, “Replacement Nuclear Warheads? Buyer Beware,” *Arms Control Today*, May 2005.

⁴⁵ National Academy of Sciences. Committee on Technical Issues Related to Ratification of the Comprehensive Nuclear Test Ban Treaty. *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty*. Washington, National Academy Press, 2002, p. 5.

Skeptics argue that SSP can accommodate minor variance in components made with LEP. Variation has always been present in nuclear weapons production. During the Cold War, when thousands of warheads of a given type were made over a period of years, small changes were inevitable: materials would vary from one batch to the next, vendors would reformulate materials slightly, processes were not completely defined, and minor design or process changes were made. While nuclear testing was available, it was impossible to test all variations. Despite these limitations, weapons were certified for use in the stockpile, indicating that some variance is acceptable.

RRW supporters argue that LEP will have increasing difficulty in maintaining weapons over the long term, as discussed in “Is LEP Satisfactory for the Long Term?” Regarding testing, it was unnecessary to test all variance between warheads because much of it fell within design parameters validated by nuclear tests. At the same time, testing was available to address uncertainties and to provide confidence in larger changes.

Is RRW Needed in Order to Provide New Military Capabilities?

NNSA Administrator Brooks maintains that the current stockpile may be wrong from a military perspective. Yields are too high, there is potential for too much collateral damage, we lack the capability to destroy buried facilities or facilities containing chemical or biological weapons, warheads could be more accurate, and they are not geared for small-scale strikes. Weapons to create electromagnetic pulse to destroy electronic equipment would be more effective if their radiation outputs were tailored to the mission, which could require modifications to the NEP. Weapons to destroy chemical or biological weapons would benefit from altered radiation outputs. Brooks said, “we must preserve the ability to produce weapons with new or modified military capabilities if this is required in the future.” He views RRW as the “enabler” for transforming the stockpile.

RRW skeptics would challenge the need for new military capabilities. They maintain that current weapons possess a vast range of capabilities that should suffice for the limited contingencies in which the United States might use them. Brooks does not claim that new capabilities are needed, only that they might be in the future. Further, they argue, many of Brooks’s examples are irrelevant to RRW. Accuracy depends mainly on the reentry vehicle and the missile’s guidance. The ability to conduct small strikes depends on command and control. There may be various ways to reduce the yield, and collateral damage, of existing weapons. Unmodified weapons can generate electromagnetic pulse, as has been known since around 1960.⁴⁶ Even modified nuclear weapons may be unable to destroy chemical or biological agents in

⁴⁶ U.S. Department of Defense and Department of Energy. *The Effects of Nuclear Weapons*. Compiled and edited by Samuel Glasstone and Philip Dolan. Washington, USGPO, 1977, p. 514.

buried facilities.⁴⁷ Accordingly, critics challenge the new-capabilities argument as a rationale for RRW.

Might RRW Permit a Reduction in Warhead Numbers? The United States retains many reserve warheads. Some are for inspection. Some hedge against a potential need for more deployed weapons, which is important because the United States has been unable to produce weapons for the stockpile since shortly after the Rocky Flats pit production plant closed in 1989. (See Appendix.) Others hedge against the failure of some weapons; for example, NNSA retains at least two warhead types for each delivery system — W62, W78, and W87 for land-based missiles, W76 and W88 for submarine-launched missiles, B61 and B83 bombs for aircraft, and W80 and W84⁴⁸ for cruise missiles. In that way, the failure of one warhead type would not compel the withdrawal of an entire class of delivery systems. Still others insure against an inability by NNSA to maintain the stockpile with LEP. While all units of a given warhead type age at the same rate, individual units differ slightly, so may fail at different times or for different reasons.

In the view of DOD and NNSA, RRW would permit a reduction in warhead numbers by increasing confidence in the warheads that remain. It would also support a production complex that can demonstrate the capability to manufacture at least small numbers of warheads for the stockpile. In that way, the United States could respond to new military requirements with new-production RRW warheads that might be tailored for specific missions rather than maintaining large numbers of stockpiled warheads, at substantial cost, in which confidence might erode over time.

RRW supporters believe that RRW creates an additional path, beyond that offered by LEP, for increasing confidence in warheads. They state that, under LEP's approach of minimizing changes to the nuclear explosive package (NEP), problems can only be resolved by attempting to reduce uncertainties through technical analyses, while RRW also provides the option of increasing margins by redesigning components to compensate for uncertainties.⁴⁹

⁴⁷ A National Academy of Sciences report stated, “An attack [on a chemical or biological weapons facility] by a nuclear weapon would be effective in destroying the agent only if detonated in the chamber where agents are stored,” and that the uncertainty of survival of an earth penetrator weapon increases with a depth of penetration greater than 3 meters. National Academy of Sciences. National Research Council. Division on Engineering and Physical Sciences. Committee on the Effects of Nuclear Earth-Penetrator and Other Weapons. *Effects of Nuclear Earth-Penetrator and Other Weapons*. Washington, National Academies Press, 2005; prepublication copy, p. 9-1 and 9-2. By this reasoning, a nuclear attack on a chemical or biological weapon facility buried at a moderate depth would probably fail.

⁴⁸ The W84 is not in the active stockpile.

⁴⁹ The weapons labs are developing a technique, quantification of margins and uncertainties (QMU), to evaluate how changes affect weapon performance. The idea is to identify key segments of a weapon's performance (e.g., high explosive detonation), the minimum and maximum values required for each segment to perform as intended, the range of uncertainty associated with those values, and the design margins. Under QMU, the labs could have confidence in the warhead if margin exceeds uncertainty at each segment. QMU could be (continued...)

Skeptics endorse stockpile reductions, but would question the need for RRW to meet this goal. They argue that other means can maintain confidence in warheads. For example, tritium gas, which is used to boost a weapon's yield (see Appendix), decays radioactively, so changing a weapon's tritium more frequently could, it is argued, compensate for uncertainties introduced by slight changes in weapon components under LEP.⁵⁰ This change can be made under LEP with no impact to the NEP. Skeptics also point out that RRW would address only one of many reasons given for a reserve stockpile, so it would seem that RRW by itself would not permit large reductions.

RRW supporters agree that enhanced boost gas could forestall some problems and should be used to do so, but note that it cannot solve others: a slight asymmetry in the implosion wave might cause the primary to fail, or a failure of the radiation case would prevent the secondary from detonating.

Will RRW Save Money? Supporters claim that RRW would save money for the following reasons. Using fewer hazardous materials in components and production processes would reduce the cost of handling, worker and environmental protection, and waste disposal. Components designed for ease of production could be produced with less equipment, in less time, and on less floor space. Components less sensitive to minor variations in dimensions and materials would have fewer production units rejected, reducing the waste stream and effectively increasing capacity. Use of more advanced warhead use-control features would permit a reduction in the cost of physical security. Increasing warhead safety would reduce the risk of plutonium dispersal in a fire, and the resulting cost. Reducing stockpile size would lower security and maintenance expenses.

Skeptics favor holding down costs, but not at the expense of confidence in the stockpile. They place more confidence in LEP, and would rather use it even if it costs more than RRW. They also anticipate that RRW would entail high transition costs for development of warhead components and production processes, construction of new nuclear weapons complex facilities, and modification of large

⁴⁹ (...continued)

used with LEP or RRW. For more on QMU, see David Sharp and Merri Wood-Schultz, "QMU and Nuclear Weapons Certification: What's under the Hood," *Los Alamos Science*, number 28, 2003: 47-53; and D.H. Sharp, T.C. Wallstrom, and M.M. Wood-Schultz, "Physics Package Confidence: 'ONE' vs. '1.0,'" *Proceedings of the NEDPC [Nuclear Explosives Design Physics Conference] 2003*, Los Alamos report LAUR-04-0496, 13 p.

⁵⁰ "In certain cases, slight changes in the attributes of a nuclear weapons component, such as those introduced by using new technologies, can be rendered unimportant by increasing the margin of performance of the weapon. By margin of performance, we mean the difference in primary yield which is expected from a normal weapon and the minimum primary yield which will drive the secondary to essentially full yield. The margin available to a specific weapon changes with time and circumstances, notably because primary yield is so sensitively dependent on the amount of tritium available in the gas system. ... There are various means to enhance the margin without resorting to underground tests ... But it seems clear that the most significant opportunity to enhance margin lies in the gas supply system. ... one obvious means is to shorten the tritium refill cycle so that large excursions in the amount of tritium do not occur." Drell, Jeanloz, et al., *Remanufacture*, p. 23-24.

numbers of warheads. Posited savings from RRW in operations and maintenance, corrected for inflation, would have to exceed these up-front investment costs for the cost argument to be valid. With RRW at a preliminary stage, skeptics doubt that RRW supporters have nearly enough data to make cost comparisons.

How Might RRW Affect the Nuclear Weapons Complex? A responsive infrastructure, including the nuclear weapons complex, is an element of the New Triad.⁵¹ Responsiveness appears to include flexibility, the ability to switch rapidly from work on one warhead type to work on another in case a defect is found that requires a prompt fix; timeliness, the ability to modify warheads or make new-design warheads if needed in time to respond to potential threats, if called for by DOD; and capacity adequate to make fixes in a reasonable time to a warhead type with many deployed units, or so that it could work on several warhead types simultaneously.

A responsive infrastructure, RRW supporters believe, requires new-design components. Components that are designed for ease of manufacture and that minimize the use of hazardous materials would permit the plants to use simpler production processes and produce at a faster rate. Conversely, by increasing confidence, RRW could enable DOD to shift its hedge against potential weapon problems from maintaining many inactive warheads to a more responsive infrastructure, thereby reducing the number of nondeployed warheads and the size of the complex needed to support the stockpile.

Skeptics would question whether an LEP infrastructure would be much less responsive than an RRW infrastructure. New-design NEP components fully supportable by nuclear test data could be done under LEP or RRW. The remaining subset of components, new-design NEP components not fully supported by test data, would involve considerable equipment and skill to produce even under RRW. Worse, such components might introduce problems, and correcting them would absorb much of the capacity of the infrastructure, reducing its responsiveness. Finally, responsiveness can be gained in ways other than component design, such as by investment in equipment, facilities, and R&D on manufacturing. Skeptics do not oppose all manufacturing improvements. Some improvements could produce components to tighter tolerances, reducing variations that might raise questions about reliability. Skeptics see a smaller stockpile as the best way to assure responsiveness by easing the burden on the production complex.

Skeptics may find the nuclear weapons complex envisioned by NNSA Administrator Brooks under RRW to be troubling:

Establishing a responsive nuclear infrastructure will provide opportunities for additional stockpile reductions because we can rely less on the stockpile and more on infrastructure (i.e., ability to produce or repair warheads in sufficient quantity in a timely way) in responding to technical failures or new or emerging threats.⁵²

⁵¹ Crouch, Special Briefing on the Nuclear Posture Review, January 9, 2002.

⁵² Brooks statement to Senate Armed Services Committee, April 4, 2005, p. 3.

If we can establish a responsive infrastructure and demonstrate we can produce replacement warheads on the same time scale in which geopolitical threats emerge — and if we can demonstrate that we can respond quickly to technical problems, then I believe we can go much further in reducing nondeployed warheads in order to meet the President's stated vision of the smallest stockpile consistent with our nation's security requirements.⁵³

Skeptics take these statements as evidence that RRW would entail a substantial production capacity and the ability to design weapons and start production quickly, thereby enabling the buildup of a larger stockpile if desired. They believe that some manufacturing processes could be upgraded under LEP, and reject the implication that only RRW could deliver a more efficient and responsive complex to support a smaller stockpile.

RRW advocates, however, maintain that the United States needs a nuclear weapons complex as Brooks described because it addresses contingencies that could well arise. The United States may need to (1) design and produce new or modified warheads quickly to meet new threats; (2) rebuild several warhead types at the same time; (3) conduct a large-scale, rapid rebuild to correct a defect in a type of warhead deployed in large numbers, and (4) rebuild a smaller stockpile on a continuing basis to avoid issues that could cause uncertainty in performance. Substantial capacity is needed to meet any of these goals, let alone all of them simultaneously. However, they argue that this capacity does not mean that the United States will build a large stockpile; the President and Congress would decide on stockpile size.

Might RRW Undermine U.S. Nonproliferation Efforts? Skeptics oppose RRW to the extent that it entails a substantial production capacity, facilitates the development of weapons with new military capabilities, or leads to testing. They are concerned that a program of that sort may appear to run counter to the U.S. commitment in Article VI of the Nuclear Nonproliferation Treaty (NPT) to “pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament ...” Further, a statement by China, France, Russia, the United Kingdom, and the United States to the 2000 NPT Review Conference reiterated “our unequivocal commitment to the ultimate goals of

⁵³ Senate Armed Services Committee hearing, Strategic Forces/Nuclear Weapons, April 4, 2005.

a complete elimination of nuclear weapons ...”⁵⁴ In this view, reaffirming the value of nuclear weapons through programs such as RRW would make it harder for the United States to achieve its nonproliferation objectives diplomatically. Member states of the NPT, meeting in New York in May 2005 to review treaty implementation, have criticized the United States, though not by name, for nuclear weapon programs, which they see as inconsistent with Article VI of the treaty.⁵⁵

RRW’s supporters counter that RRW will increase confidence in the reliability of weapons and in the ability to certify them over the long term. As a result, RRW will reduce the probability that the United States will resume nuclear testing and will permit a substantial reduction in the U.S. nuclear stockpile, both of which could have a positive effect on nonproliferation. In addition, some may take the view that an RRW program that facilitated the development of nuclear weapons with new military missions could help dampen proliferation by strengthening deterrence.

Might LEP or RRW Lead to Nuclear Testing? RRW’s supporters and skeptics both prefer to avoid nuclear testing. The Administration has continued the

⁵⁴ “Statement by the Delegations of France, the People’s Republic of China, the Russian Federation, the United Kingdom of Great Britain and Northern Ireland, and the United States of America,” introduced in “Statement to the 2000 NPT Review Conference,” by H.E. Hubert de la Fortelle on behalf of the U.N. permanent five nuclear weapon states, May 1, 2000; available at [<http://www.ceip.org/programs/npp/npt2000p5.htm>].

⁵⁵ See, for example, Ambassador Wernfried Koeffler, Head of Delegation, Austria, in a statement to the 2005 NPT Review Conference (p. 4), said, “Our concern that nuclear weapons are still central to strategic planning is increased by reports of intentions to develop new nuclear weapons or alter their design for new uses. Even the affirmation that only concepts are being studied is not reassuring.”

nuclear test moratorium, though it has asserted it would test if required.⁵⁶ That has not been needed because DOD has no requirement for nuclear weapons with new or modified capabilities, and because the Secretaries of Defense and Energy have been able to certify the stockpile without testing.⁵⁷ Because the Administration does not support the Comprehensive Test Ban Treaty,⁵⁸ it has not spelled out arguments against testing. It could be, however, that part of the rationale for avoiding testing is political, as testing could cause massive protests domestically and internationally. Further, most nations would likely view resumed U.S. testing as a clear breach of U.S. obligations on behalf of nuclear disarmament and could lead to the unraveling of the nuclear nonproliferation regime and to testing by others.

NNSA argues that RRW would reduce the need for testing. Linton Brooks said, “not only is the reliable replacement warhead program not designed to foster a return to nuclear testing, it is probably our best hedge against the need sometime in the future to be faced with the question of a return.”⁵⁹ Components could be designed to be less sensitive to minor changes in materials and processes and to permit looser tolerances. As a result, uncertainties that might prompt a nuclear test on current weapons might be acceptable with RRW components.

Skeptics endorse a continuation of the nuclear test moratorium, but fear that changes under RRW that NNSA claims would reduce the need for testing could actually increase it. Small changes to the NEP that were within the parameters validated by past nuclear tests could be done under LEP. It is as yet unclear if changes made under RRW would be within these parameters; changes of greater magnitude could undermine confidence in the warhead and lead to testing.

Might RRW Enable an Increase In Inherent Warhead Security? There are two aspects to warhead security — access control and use control. The first is a matter of physical protection and is the responsibility of DOD or DOE. The second is ensuring that anyone who gains unauthorized access to a warhead is not able to detonate it. In the wake of the 9/11 attacks, both have increased in importance. For example, NNSA’s FY2002 request for Safeguards and Security was \$448.9 million, while the FY2006 request is \$708.5 million. Use control has always been part of warhead design. In the earliest days, fissile materials were reportedly kept separate

⁵⁶ Linton Brooks testified, “we believe the nation must be prepared to carry out an underground nuclear test in the event of unforeseen problems that can’t be resolved by other means.” U.S. Congress. House. Committee on Armed Services. Strategic Forces Subcommittee. Hearing on the FY2006 budget request from the Department of Energy on Atomic Energy Defense Activities, March 2, 2005.

⁵⁷ Senate Armed Services Committee hearing, Strategic Forces/Nuclear Weapons, April 4, 2005.

⁵⁸ The treaty would ban nuclear explosions. It was opened for signature in 1996 but has not entered into force. The U.S. Senate rejected it in 1999. See U.S. Congress. Congressional Research Service. *Nuclear Weapons: Comprehensive Test Ban Treaty*. CRS Issue Brief IB92099, by Jonathan Medalia. Updated periodically.

⁵⁹ Senate Armed Services Committee hearing, Strategic Forces/Nuclear Weapons, April 4, 2005

from bomb casings, in part for control.⁶⁰ For many years, weapons have used permissive action links, which require a code to activate the weapon. Now, with a higher threat of terrorist attack, RRW supporters claim that further modifications to the weapon for use control are in order. Linton Brooks, discussing RRW, stated:

We now must consider the distinct possibility of well-armed and competent terrorist suicide teams seeking to gain access to a warhead in order to detonate it in place. This has driven our site security posture from one of “containment and recovery” of stolen warheads to one of “denial of any access” to warheads. This change has dramatically increased security costs for “gates, guns, guards” at our nuclear weapons sites. If we were designing the stockpile today, we would apply new technologies and approaches to warhead-level use control as a means to reduce physical security costs.⁶¹

Skeptics say that physical security and existing use-control features are quite sufficient to protect warheads against theft by terrorists. The record in this regard is exceptional. Warhead vulnerability has been reduced since the end of the Cold War by withdrawing thousands of tactical nuclear weapons from Europe and from Navy ships, and by reducing the number of deployed strategic nuclear warheads sharply. General James Cartwright, USMC, Commander, U.S. Strategic Command, said, “I am comfortable that we have the [nuclear] weapons protected and that we are moving to a posture that will improve that protection in light of the changing threat.”⁶² Skeptics also question if DOE and DOD would reduce physical security even if enhanced-security warheads were deployed. At any rate, in this view, Russian nuclear warheads and materials are at much higher risk, so U.S. programs to secure them would be a better investment than improvements to U.S. warheads.

Skeptics question the merits of redesigning warheads to incorporate new use-control features. So doing might reduce confidence in the warheads, at high cost, and for little potential benefit. According to Robert Peurifoy, a former Vice President at Sandia National Laboratories, “Use control features were originally intended to delay the unauthorized use of a nuclear weapon by friendly forces, including U.S. custodians. It has now magically transformed in the minds of many to the prevention of unauthorized use by terrorists. I don’t believe this can be done.”⁶³

Might RRW Enable an Increase In Warhead Safety? While the United States has taken steps to increase the safety of its warheads against lightning, fire, impact, etc., not all warhead types incorporate all existing safety features. Some use conventional high explosive (CHE) rather than insensitive high explosive (IHE); the latter will not detonate in various accidents, while the former can, possibly scattering

⁶⁰ Thomas Cochran, William Arkin, and Milton Hoenig, *Nuclear Weapons Databook, Volume I, U.S. Nuclear Forces and Capabilities*, Cambridge, MA, Ballinger, 1984, p. 6. See also *ibid.*, pp. 30-31.

⁶¹ Brooks statement to Senate Armed Services Committee, April 4, 2005, p. 4.

⁶² Testimony at Senate Armed Services Committee hearing, Strategic Forces/Nuclear Weapons, April 4, 2005.

⁶³ Email from Robert Peurifoy to the author, March 26, 2005.

plutonium. Some warheads lack fire-resistant pits, which are designed to increase the time and temperature that a warhead exposed to fire will contain plutonium.

RRW advocates make the following argument. The technology of current warheads is frozen in the 1980s, and LEP perpetuates that technology. The only way to move beyond it is to use new-design components that incorporate current advances. Since the United States will retain its stockpile for an indefinite time, the cost of the safety gains would be amortized over many years. To enhance safety, the RRW program may consider ways to modify warhead components, including those in the NEP, to increase fire resistance.

Skeptics believe that warheads are quite safe, and that safety has improved over the years thanks to safer designs and improved handling procedures. They are concerned that some safety changes to the NEP would go beyond what is supported by nuclear test data and could jeopardize reliability. For example, it is critically important to the performance of the primary, and thus of the secondary, that the pit implode with reasonable symmetry. A vast amount of effort has gone into developing such pits and determining the bounds of “reasonable.” Because IHE is significantly less energetic than CHE, more IHE must be used to obtain the same implosive force. But using a larger amount of less energetic material would alter the implosion wave, necessitating other adjustments in order to use the same pit.

Some safety-related changes would, skeptics believe, offer little value. For example, the W88 or W76 warheads for Trident missiles could be candidates for backfitting with IHE. They use CHE because the Navy sought to maximize yield-to-weight. Using IHE on the W88 would have reduced range by 10 percent, or warhead yield by “a modest amount,” or the number of warheads the missile could carry from eight to seven.⁶⁴ A 1990 study expressed concern about the safety of CHE.⁶⁵ Sidney Drell, the panel chairman and lead author of the study, however, stated in 2005 that further studies revealed that the CHE in the W88 would not detonate even if subjected to a harder knock than was realized in 1990, and that little would be gained by substituting IHE in the warhead because the missile itself used a very energetic propellant that is relatively easy to detonate. An accident that caused the propellant to detonate could break apart the warheads, scattering plutonium, regardless of the explosive used on the warhead. Unless the missile was redesigned to use a less energetic propellant, which would be very costly, replacing CHE with IHE in the warheads would produce little gain in safety. Further, because CHE and IHE are very different in terms of energy density, burn characteristics, etc., Drell believes that there is no way that IHE could be substituted for CHE without nuclear testing.⁶⁶

Might RRW Reduce Adverse Consequences of Aging? RRW supporters hold that the effects of aging can be reduced. Materials less sensitive to

⁶⁴ U.S. Congress. House. Committee on Armed Services. *Report of the Panel on Nuclear Weapons Safety*. Committee Print No. 14, 101st Congress, 2nd Session, p. 28. By Sidney Drell, Chairman, John Foster, Jr., and Charles Townes.

⁶⁵ Ibid., p. 32.

⁶⁶ Information provided by Sidney Drell to the author, March 16, May 3, and May 4, 2005.

aging can be used, processes can be better characterized so that they can be repeated more precisely, and new components can be designed to use such materials and processes.

Skeptics feel that RRW advocates have overstated the problem and minimized the ability of LEP to cope with it. They feel that LEP can continue to correct aging problems, as it has for many years. They hold that changes in materials must be done with extensive study to determine if the material will work as did the original, but assert that distinguishing the “large” changes of RRW from the “small” changes made under LEP is largely a matter of semantics as long as the changes are made under the condition that they will not require the resumption of nuclear testing.

Might RRW Enable Reduced Use of Hazardous Materials? Warheads and their manufacture use many hazardous materials (hazmat). Hazmat require special handling of materials and equipment: glove boxes, other layers of containment, filtration of air vented into the atmosphere, disposition of scrap material and contaminated solvents, and compliance with numerous environmental and safety regulations. Regulations now ban some industrial solvents that were used to produce current warheads. Minimizing or eliminating hazmat would produce benefits for cost, ease of production, and worker safety. During the Cold War, warheads used these materials to save weight, or because a particular material was the standard way to solve a design problem. RRW advocates believe that advances in weapons knowledge over the past quarter-century and establishing hazmat reduction as a design goal make it possible to design components that minimize hazmat usage.

Skeptics agree that reduction of hazmat is a worthy objective, but question if it is worth the costs and risks. Redesign, validation, and production of components would require extensive testing and study, and would run the risk that a different material, especially in the NEP, could impair reliability. New materials might impair reliability if they decomposed in an unanticipated manner. Existing components and materials have become increasingly well characterized. That knowledge base reduces the advantage of eliminating hazmat. Some skeptics would retain existing components, materials, and processes to the extent possible, even if that meant retaining hazmat, on grounds that that is the surest way to retain confidence in reliability. They would consider having dedicated production lines if needed to produce some materials, and would consider filing for waivers to hazmat regulations if needed to continue using such materials. Others would consider redesign of some non-NEP components to eliminate hazmat if it could clearly be demonstrated, on a case by case basis, that the benefits were substantial and the uncertainties were minimal.

Policy Options for Congress

RRW is a new program with no specific, tangible product yet defined. In deciding how to proceed on RRW, Congress has a number of options available to it.

Decide Whether and How to Proceed. As with any program, Congress could choose to continue RRW as requested or terminate it. Several options exist

between those extremes. Congress could allow NNSA to pursue RRW and LEP as complementary programs. It could limit RRW to modification of components and bar the program from considering new-design warheads. It could bar RRW from making warhead changes that would increase military capability or that could reasonably be expected to lead to nuclear testing. It could delay a decision on such choices pending the outcome of the FY2005-FY2006 RRW study.

Clarify the Scope of RRW. Because RRW is a new program, its scope is in the process of being defined. Congress might wish to help focus and shape the program by asking NNSA to answer a number of questions to better define it.

- What design changes does NNSA envision making in warhead components with RRW that could not be made with LEP?
- If NNSA proceeds with LEPs for W76 and W80, would that truly preclude transformation of the nuclear weapons complex for decades? If so, when must a choice between LEP and RRW be made?
- Will RRW involve the construction of one or more new sites for the nuclear weapons complex outside existing sites? Will it involve construction of new facilities at existing sites? What upgrades to facilities are envisioned to foster a responsive infrastructure?
- Will RRW lead to the closing of any existing nuclear weapons complex sites?

Impose Legislative Requirements. Congress may also wish to define the bounds of RRW legislatively by requiring that

- RRW components stay within the design parameters validated by nuclear testing.
- RRW not be used to enhance military capabilities or provide for new military missions.
- The number of non-deployed warheads be significantly reduced if RRW proceeds.

Require a Plan and Budget for RRW. It may be too early to expect NNSA to provide a detailed program plan and a rough budget estimate for the FY2006 budget cycle because RRW did not exist as a funded program until December 2004. Congress may, however, wish to require NNSA to provide a five-year budget and plan with its FY2007 budget submission.

Appendix: Nuclear Weapons and the Nuclear Weapons Complex

This report refers to nuclear weapons design, operation, and production throughout. This Appendix describes key terms, concepts, and facilities as an aid to readers not familiar with them.

Current strategic (long-range) and most tactical nuclear weapons are of a two-stage design.⁶⁷ The first stage, the “primary,” is an atomic bomb similar in concept to the bomb dropped on Nagasaki. It provides the energy needed to trigger the second stage, or “secondary.”

The primary has a hollow core, often called a “pit,” made of fissile plutonium (isotope number 239). It is surrounded by a layer of chemical explosive designed to generate a symmetrical inward-moving (implosion) shock front. A system injects “boost gas”—a mixture of deuterium and tritium (isotopes of hydrogen) gases—into the pit, and there is a neutron generator. When the explosive is detonated, the implosion compresses the plutonium, greatly increasing its density and causing it to become supercritical, so that it creates a runaway nuclear chain reaction. Neutrons drive this reaction by causing plutonium atoms to fission, releasing more neutrons. But the chain reaction can last only the briefest moment before the force of the nuclear explosion drives the plutonium outward so that it can no longer support a chain reaction. To increase the fraction of plutonium that is fissioned—boosting the yield of the primary—the neutron generator injects neutrons directly into the fissioning plutonium. In addition, intense heat and pressure cause the deuterium-tritium mixture to undergo fusion. While the fusion reaction generates energy, its purpose is to generate a great many neutrons. A metal “radiation case” then channels the energy of the primary to the secondary.

The secondary contains lithium deuteride and other materials. The energy from the primary implodes the secondary, causing fusion reactions that release most of the energy of a nuclear explosion.

The primary, radiation case, and secondary comprise the “nuclear explosive package.” Thousands of other “nonnuclear” components, however, are needed to create a weapon. These include a case for the bomb or warhead, an arming, firing, and fuzing system, use-control devices, and more.

Nuclear weapons were designed, tested, and manufactured by the nuclear weapons complex, which is composed of eight government-owned contractor-operated sites as well as the federal agency, the National Nuclear Security Administration (a part of the Department of Energy) that manages the nuclear weapons program. The sites include the Los Alamos National Laboratory (NM) and Lawrence Livermore National Laboratory (CA), which design nuclear explosive

⁶⁷ U.S. Department of Energy. *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, DOE/EIS-0236, September 1996, summary volume, p. S-4. This page contains further information on nuclear weapon design and operation.

packages; Sandia National Laboratories (NM and CA), which design the nonnuclear components that turn the nuclear explosive package into a weapon; Y-12 Plant (TN), which produces uranium components and secondaries; Kansas City Plant (MO), which produces many of the nonnuclear components; Savannah River Site (SC), which processes tritium from stockpiled weapons to remove decay products; Pantex Plant (TX), which assembles and disassembles nuclear weapons; and the Nevada Test Site, which used to conduct nuclear tests but now conducts other weapons-related experiments that do not produce a nuclear yield. These sites are now involved in disassembly, inspection, and refurbishment of existing nuclear weapons.

Pit production is the most controversial aspect of nuclear weapons production, and the one most closely linked to RRW. Rocky Flats Plant (CO) used to produce pits, but that work was halted in 1989 due to safety concerns. Since then, the United States has not made any pits that have been certified for use in stockpiled warheads — and has therefore been unable to make entire new warheads (excepting for a small number built shortly after Rocky Flats closed using pits that that plant had made). Los Alamos has established a small-scale pit production plant at its plutonium building, Plutonium Facility-4 (PF-4). PF-4 has produced several pits, but Los Alamos has not completed the work needed to certify them for use in the stockpile. NNSA anticipates that that work will be completed in FY2007, and that PF-4 will achieve a capacity of 10 pits per year beginning in FY2007. Los Alamos further believes that it would be difficult to expand PF-4's capacity enough to support the stockpile, though others challenge that view, arguing that if pit lifetime proves longer than anticipated, or if the future stockpile declines more than anticipated, a smaller capacity of an expanded PF-4 would suffice.

NNSA's proposed solution is to build a new Modern Pit Facility (MPF), with a capacity of 125 pits per year, to be operational beginning around 2021.⁶⁸ RRW might enable greater capacity at PF-4 or MPF by simplifying components and making manufacturing processes more efficient. Increased capacity at PF-4 might enable that facility to substitute for MPF, if pit requirements drop sharply, or to serve as a backup to MPF so as to avoid the disruption to nuclear weapons production that occurred with the shutdown of Rocky Flats Plant. Either of these options would require a capacity at PF-4 several times larger than the 10 pits per year currently projected for it.

⁶⁸ Information provided by NNSA, May 10, 2005.